Benefits, Advantages & Challenges

Introduction

A discussion period followed each of the nine technical sessions. As announced by Technical Chair Robert Frisbee at the beginning of the workshop, feedback regarding the "benefits, advantages, and challenges" was solicited from all attendees for the session's area of research. The essence of each input was typed into a computer by General Chair Clark Hawk and projected for viewing by everyone present. Corrections were made as prompted by viewers.

1. Antimatter

Benefit (B) and uncharacterized comments appearing to note Advantages (A*) or Challenges (C*)

B: Super high energy density

A*: Small containment volume

C*: Have to figure out how to utilize the energy yield efficiently

A*: Positrons great for endoatmospheric uses; in space it doesn't matter

C*: Is it desirable to look at the end stages of using antimatter – eg, properties of antihydrogen – even though production is still a big issue? YES – should not cost a lot of money for AMO physics expts. Bose-Einstein condensates of antiparticles may be in sight.

C*: There are ways to capture antiprotons with high efficiency, but it takes a lot of work – will take interest of NASA or DOE – high energy physicists not particularly interested in big quantities at present

C*: Cost issues associated with handling antimatter in an engine? $60M/microgram will be cost of antiprotons. $6M/mg for positrons. Infrastructure costs of using it may be very high.

A*: Could give physically smaller and lighter vehicle? (Seems to be open to debate). Does this have to be competitive with $100/lb goal for payloads to LEO?

2. Advanced Chemical & MHD Propulsion

Benefits (B), Advantages (A) & Challenges (C, or C* if not characterized during session)
C – Traajectory optimization
C - De-mythisizing the technology – bldg research base to understand
B – getting cost/lbm of PL down; launching on demand; improved range
B- cost savings thru smaller launch vehicles.
C – Small percentage changes in chemical propulsion can have high leverage on vehicle size and cost
C - Simplify combined cycle (mechanically & thermodynamically?)
C - Reduce infrastructure (standing army) costs – emphasize life cycle costs.
C* - Emphasize "system of systems" approach
C* - MHD, weakly ionized gas, controls, will have impact on vehicle design

3. Beamed Momentum Propulsion

Benefits (B), Advantages (A) & Challenges (C)
B – Hi delta V missions w acceptable flight times.
B - Low mass structures
B – Increased launch opportunities, frequent launch dates
B – Non-Keplarian orbits – hovering maneuvering
B – Pizzazz – public appeal
B – Lower cost to facilitate robotic missions
B – Non-nuclear
B – Propellantless (nearly)
C – Potentially long trip times
C – Difficult to stop
C – Materials survivability for sails
C – Must start in higher orbits (chemical stage needed to get them there.
C – Overcoming deep gravity wells.
C – Can't use in-situ resources (does this really belong here?)
B – Beginning to validate plasma physics and MHD technologies in new applications
C – How best to combine various effects to make a more workable whole?

4. Beamed Energy Propulsion

Benefits (B), Advantages (A) & Challenges (C)
A – Solar thermal ready to fly
C – Beamed power flight demo within 2-3 years desired.
A – Solar thermal - Shorter trip times than electric, less mass than chemical
A – Laser thermal – potential low cost launch by putting propulsion weight (most of it) on the ground.
C – Space based energy/laser source
A – Solar thermal – trade Isp for thrust
A – Solar thermal has lots of applications (LEO, GEO, C3, & planetary)
A – Monocycle Laser – adjustable (trade Isp for thrust.)

5. Advanced Electric Propulsion

Benefits (B), Advantages (A) & Challenges (C)
A – Wide range of thrust capability
A – Devices are real and exist and are available
C – Miniaturization and higher power levels.
A – Dramatic reduction in mass and trip time (for planetary missions) (Power dependent)
A – Development cost is relatively small
A – Operational simplicity
C – Availability of power systems to meet the thruster capabilities
C – Long operating times envisioned
A – Wide range of Isp available
C – Long duration testing to validate life (can be done on ground test)
A – High thrust density in contrast to sails
C – Capability of ground test facilities to handle life test
C – Low thrust trajectory brings its own set of analysis problems.
C – Political issue of nuclear power sources for EP
A – Lots of theoretical base and understanding exists. (Can build upon plasma base of knowledge.)
A – Valuable spinoffs exist (diamond spray capability)
A – Variety of propellants (in-situ)
A – Demonstrated efficiency & reliability
A – Modular

6. Tethers, Towers & Skyhooks

Benefits (B), Advantages (A) & Challenges (C)
A – Propellantless
A – Reusable, reusable, reusable (Validate without loss of “launcher”)
C – Materials (Available materials OK for tethers but not for towers?)
A – Access via sub-orbital launch to tether
C – Rendezvous issues
C – Tether must avoid traffic (Control of orbit, tracking of tether tip, etc.)
A – On board propellantless propulsion system for orbit raising, etc.
C – Deployment issues (snagging, etc)
C – Orbit inclination changes slow (depend upon electric thruster aspects)

7. Fission Propulsion

Benefits (B), Advantages (A) & Challenges (C)
A – Greatly reduced trip times & technical risk
C – Build US data base for MHD augmentation into the technology
A – Enables missions un-doable with chemical propulsion
A – Space law exists covering nuclear sources in space
A – Significant technology heritage transferred from chemical business
C – Reducing weight of reactors and shielding
C – Public perception that nuclear is bad. (Education is needed. How to engage FAS in positive way?)
A – Commonality with ground based systems
A – Energy rich missions at destination
A – Reduce missions risk (reduced time for manned missions, weight capability for robotic missions)
A – Dual use for reactor (power source at destination)
A – Ideally suited for outer planetary missions
A – Nuclear submarine technology illustrates safety base.

8. Interstellar Missions

Benefits (B), Advantages (A) & Challenges (C)
A – Stretch goal (the most propulsion intensive goal)
C – Programmatically, these types of concepts get pushed out in time and don't get considered for relatively near term funding.
C – require high energy density, hi Isp, hi strength, light weight materials.
C – Extremely long life requirements
C – Off board power & or propellant (runway propellants, beamed energy)
C – Systems must be autonomous due to speed of light communication problems.
A – Near term bits and pieces of the technology req'd are being worked on today and can- provide base to build on (lasers, solar sails, etc.)
A – "Sales" value of far out thinking

9. Fusion Propulsion

Benefits (B), Advantages (A) & Challenges (C)
A – Fusion systems offer extraordinary advantages on trip times.
C – Size of the systems/investment can be a disadvantage (any with a low threshold mass?)
A – Different figures of merit for propulsion than terrestrial systems
C – Need DoE involvement/investment to achieve application
A – In-situ fuel (helium 3)
C – Unambiguous fusion demo
C – Pulsed power, lasers, and magnets demo (driver efficiencies)
C – How efficiently are we converting power to thrust? (e.g. magnetic nozzles)
C – Effects of neutron flux on structure